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ABSTRACT

The effect on achievement of sequential organization of subject matter in programed instruction, the interaction of sequence with verbal ability, and the effect of two types of anxiety on learning were examined in this study. Subjects were randomly assigned to either a group in which program frame sequence had been scrambled by means of a table of random numbers or to a group in which the program frames were logically sequenced. Two programs dealing with heart disease were employed: one program contained material of some familiarity to the subjects and the other contained technical content which was new to the subjects. The results indicated that, as expected, the type of sequence caused significant differences in achievement on the unfamiliar materials but not on familiar content. Interactions between sequence and verbal ability were not found, though there was some evidence for triple interactions among sequence, verbal ability, and anxiety. The results provided further evidence that a pupil's prior familiarity with subject matter may be an important moderating variable in determining which instructional mode or type of content organization leads to superior achievement. (Author/JY)

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The Effect of Sequence and Familiarity With Subject Matter In Achievement From Programed Instruction

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City College, City University of New York

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Summary

The purpose of this study was to examine the effect of sequential organization of subject matter in programmed instruction on achievement. The interaction of sequence with verbal ability, and two types of anxiety were also examined.

Subjects were randomly assigned to either a group in which program frame sequence had been scrambled by means of a table of random numbers, or to a logically sequenced group. Two programs dealing with heart disease were employed; one program contained material of some familiarity to the present sample and the other contained technical content which was new to the subjects.

The results indicated that, as expected, sequence led to significant differences in achievement on the unfamiliar materials, and not on the familiar content. Interactions between sequence and verbal ability were not found, though there was some evidence for triple interactions among sequence, verbal ability and anxiety.

The results provided further evidence that a pupil's prior familiarity with subject matter may be an important moderating variable in determining which instructional mode, or type of organization of instructional content leads to superior achievement. The importance of this variable in instructional design, and attribute by treatment interactions was discussed.

Introduction

The sequence with which instructional material is presented to pupils is a subject of considerable concern from a number of different theoretical positions. Skinner (1954, 1965) advocates that scrupulous attention be paid to the sequence with which programed material is organized in order to maximize the contingencies of reinforcement. From a different point of view, Gagné (1968) also recommends attention to the sequence with which different types of subject matter are taught, such that subordinate concepts should be taught prior to superordinate ones. Contemporary concern with learning hierarchies is yet, of course, another index of the importance attached to the sequence with which subject matter is taught. It is, therefore, paradoxical that this many-sided attention to sequence has not been accompanied by solid empirical evidence confirming the importance of sequential subject organization. On the contrary, in the area of programed instruction (PI) a number of studies indicated that there were no achievement differences between presenting different instructional programs in a logical or random sequence. The first purpose of the present research, therefore, was to investigate the sequence problem in an attempt to demonstrate that the unanticipated findings in this area were attributable to the failure in previous research to vary the prior familiarity subjects (Ss) had with the material.

A further purpose of the present research was to study the interaction between a number of individual difference variables and sequence.

The presumed disorganization and greater difficulty of a scrambled, compared to a logical sequence suggested that this variable might well interact with intelligence, and with anxiety. The study of such interactions has come to be known as aptitude, or attribute by treatment interactions (ATI), which have as their aim the demonstration that optimal instructional methods vary with individual difference characteristics of subjects.

The major general hypothesis of this investigation was an extension of a construct found useful in reconciling findings regarding the issue of response mode to PI (Tobias, 1970; Tobias & Abramson, 1971). Specifically, it was hypothesized that the effect of sequence was modified by Ss' prior familiarity with the subject matter. On familiar materials Ss had a general outline of the structure of the subject and even a scrambled sequence could facilitate achievement since each frame may review a particular aspect of the overall content. In this manner a scrambled sequence acts much like a flashcard in facilitating the recall of details of a subject matter whose general outlines are well known. On new and unfamiliar content, on the other hand, Ss had no organizational scheme of the domain into which each frame might fit; hence they ought to learn significantly less from a scrambled than from a regular sequence on new, but not on familiar materials.

Review of the Literature

The sequence with which instructional material appears is especially important in PI. Skinner (1954, 1965) emphasized the

importance of sequence both explicitly and implicitly. Explicitly, Skinner wrote that PI presents "carefully designed material in which one problem can depend upon the answer to the preceding [1954, p. 90]." Implicit reliance on careful sequencing of material is seen by the prescription that programs should advance only in small steps from one item to the next in order to maintain acceptably low error rates. Clearly, a high ratio of success can be guaranteed only if the frames are carefully arranged so that each item presents only a bit more information than the preceding one. Niedermeyer (1968) quotes Markle's definition of PI as a "reproducible series of instructional events [p. 302]." From this point of view, precise sequence and PI are virtually synonymous.

Despite the importance attached to a well ordered logical sequence by workers in PI support for this position is sorely lacking. A total of eleven studies of the sequence problem (Brown, 1970; Niedermeyer et al., 1969; Payne, et al., 1967; Wodtke, et al., 1967; Stolurow, 1964; Levin & Baker, 1963; Roe, 1962; Roe, et al., 1962; Gavurin & Donahue, 1961; and Zuckerman, et al., 1961), have been reported. Only two of these (Brown, 1970; Roe, 1962) found achievement differences attributable to frame sequence. Since this literature was reviewed by Niedermeyer (1968) in some detail only the major studies in this area, as well as the more recent ones will be reviewed here.

Brown (1970) used a program composed of two parts; the first 89 frames dealt with mathematical notation and the latter 40 required the application of material learned in the first section. No achievement

differences were found between a logical and a scrambled group for the introductory material, but the differences between the groups on the application of previously learned materials were significant. Brown interprets these results as supporting the view (Gagné, 1968) that content which is low in the hierarchy of a field is relatively unaffected by scrambling, compared to materials higher up in that hierarchy.

An interpretation of Brown's findings in terms of S's familiarity appears equally plausible. On the introductory material an untreated control group obtained a mean score of 69% (Brown, 1970, p. 43) despite the fact that they were not exposed to the program at all. Clearly these Ss and, presumably, the experimental groups which were selected from the same population had substantial prior familiarity with this material, and scrambling may, therefore, not be expected to lead to achievement differences. On the latter part of the material the control group obtained a mean posttest score of 21.6%. On this subject matter where prior familiarity was low, achievement differences due to scrambling would be expected from a familiarity formulation.

Niedermeyer, Brown and Sulzen (1969) found no achievement differences among a logical, scrambled, and reversed order group. Since these writers used a modified version of the program employed by Brown (1970) the difference between the findings of the two studies is presumably attributable to differences in Ss and procedures employed. Brown used tenth and eleventh grade Ss with a mean IQ of 122, whereas Niedermeyer, et al. used ninth grade Ss with a mean IQ of 112.

Furthermore, Brown employed a longer version of the program, and different posttests than those used by Niedermeyer et al. In the latter study the mean error rate with the logical sequence was 30%, well above tolerable limits for a linear program. Of some interest for present purposes was the finding that group differences on the familiar introductory concepts, the first 70 frames, were much smaller than the differences for the presumably more novel, technical problem solving questions on the 40 final frames of this program.

Payne, Kratwohl, and Gordon (1967) compared logical and random sequencing of three programs containing a total of 164 frames in the area of elementary measurement and statistical concepts. No differences between sequences were found, nor was there any relationship with intellectual ability. The program error rates (1% for the logical and 4% for the random sequence) also did not differ. The researchers compared these error rates to previous investigations using the same program and indicated that the sample employed had more prior knowledge of the subject matter than had prior samples. The writers indicated that S's familiarity with the content reduced the sensitivity of the criterion test employed. It would appear equally possible that, in view of the high entry behavior, the program served as something akin to a review exercise in which sequence was not particularly important since Ss had already organized the subject matter, and both the logical and random sequences were comparable to a flashcard review of isolated facts. If this was indeed the case, differences between scrambled and logical sequences would not have been expected.

Wodtke et al. (1967) compared scrambled and logically sequenced programs in two areas. Programs were presented via computer terminals, and the subject population consisted of college students. One of the programs taught discrete facts about the ear for which no sequence effects were expected since the subject matter was discrete. The program for which achievement differences were expected dealt with different number bases, and contained 74 frames. No achievement differences attributable to sequence were found for either of the programs.

Of special interest was Wodtke's report that 90% of the Ss were reported to have zero scores on a pretest of the number bases program. This finding suggests, of course, that there was little prior knowledge, and would appear to contradict the rationale being developed, that lack of significant differences for the sequence effect were attributable to prior learning of the subject matter taught. Experience with two prior studies using a program dealing with different number bases (Tobias & Weiner, 1963; Tobias & Williamson, 1968) has indicated that low prescores do not necessarily mean little prior familiarity in this area. Typically Ss are unable to count in different number bases when asked to do so on a pretest, but college Ss often have a good understanding of the logic of different number bases, and once they are exposed to several examples of arithmetic computations with bases other than 10, little difficulty is experienced in recalling prior learning, or in generalizing to new situations despite initially low pretest scores.

Levin and Baker (1963) employed a geometry program which was presented to elementary school Ss in standard and partially scrambled

form. The fourth unit of the program contained a total of 60 frames, and was scrambled in three blocks of 20. The blocks themselves were presented in logical order. The program was exposed to Ss three times, in addition to a pretest. The results indicated that there were no differences between the two sequences. A review of these procedures suggests that Ss had ample opportunity to develop familiarity with the subject matter from three presentations of the material, together with the pretest, and logical sequencing on the first three units to override the effects of the slight scrambling imposed by the investigators. Roe et al (1962) employed a 71-frame program on elementary probability theory using college freshmen. No achievement differences were found, nor did error rates on the program differ, for a logical and a scrambled group. When Roe (1962) revised this program very slight differences were found between the scrambled and logical versions of the program.

Anxiety

There is a strong rationale for expecting an interaction between anxiety and program sequence. The high ratio of reinforcement present in PI, the hierarchial and sequential organization of the materials, and the low level of uncertainty experienced by S working on the instructional materials are such that programmed devices ought to be especially beneficial for highly anxious individuals. When frame sequence is scrambled in a content area with which S is unfamiliar the presumed advantages of the programed format disappear. Therefore, one would

expect that anxious Ss would find the scrambled sequence especially debilitating to their achievement. An interaction between anxiety and achievement was expected on unfamiliar materials, though not on content with which Ss had previous familiarity. On the latter kind of material it was reasoned that scrambling the frame sequence did not alter those attributes of PI presumed to be especially advantageous for anxious individuals.

Despite the strong rationale for an interaction between achievement from PI and anxiety research in this area, reviewed in detail elsewhere (Tobias & Abramson, 1971), largely fail to confirm the presence of such an interaction. Two critical problems have been identified in previous research relating anxiety to PI. The first of these is the questionable assumption that the anxiety reflected by S's score on a questionnaire is actually operative while the student is working on the research materials (Tobias, 1970). Observation of Ss in previous anxiety studies (Tobias & Williamson, 1968) indicated that such an assumption might well be unwarranted. In another study an attempt was made to ascertain that the anxiety variable was in fact engaged during the research situation by inducing stress in addition to having anxiety measures available (Tobias & Abramson, 1971). Despite this procedure there was still no clear-cut evidence that anxiety was in fact present while Ss were working on the research materials.

Spielberger's work (1966; Spielberger, Lushene, & McAdoo, 1971) offered a possible answer to the problem of the engagement of anxiety during the research task. Spielberger suggested that the anxiety

construct may well be composed of two components which had previously not been separated. The first of these Spielberger called A-Trait which is conceptualized as the relatively lifelong tendency of individuals to respond to evaluative situations with stress and feelings of negative self-regard. The second component A-State deals with is the degree to which anxiety is engaged in specific situations. A-State anxiety is expected to fluctuate over time, and is viewed as being situationally determined. The operational measures of these constructs is the State and Trait Anxiety Inventory, or STAI (Spielberger, Gorsuch & Luschene, 1966). O'Neil, Spielberger, and Hansen (1969) interspersed a brief five-item version of the A-State during a learning task administered via computer assisted instruction. The results indicated that A-State measures had a high relationship with learning scores whereas A-Trait measures did not. These studies, thus, suggested that the failure to establish a relationship between learning from PI and anxiety might be due to the fact that most studies utilized A-Trait measures rather than A-State.

Another problem raised by previous research dealt with the difficulty of the materials. Previous research has suggested that anxiety interferes with achievement only when the materials are relatively difficult; achievement on easy materials may well be facilitated by anxiety. The difficulty variable was investigated by Tobias and Abramson (1971) in the context of PI. Two sections of a program of varying difficulty were employed; one part dealt with familiar content and had an error rate of approximately 3%, and the second section dealt

with relatively novel technical material and had an average error rate of 25%. Students were randomly assigned to a constructed response condition with reinforcement, without reinforcement, and a reading condition. The expected ATIs with anxiety on the difficult material were not found. The outcome of that investigation (Tobias & Abramson, 1971) suggested that for anxiety to interact with instructional mode in a meaningful context levels of anxiety well beyond the 25% obtained in that experiment may be needed. O'Neil, Spielberger, and Hansen (1969) found strong relationships with A-State anxiety on material with difficulty rates of approximately 60%. In the present investigation it was expected that the error rate for the group receiving a scrambled sequence might well approximate that found by O'Neil et al. in their investigation, and hence an ATI with anxiety was expected.

Verbal Ability

It would appear logical that students of high intellectual ability should be less affected by scrambling the sequence with which subject matter is presented than less able students. Their ability ought to enable such students to search out relationships, reorganize subject matter, and re-sequence materials as they are processing them to a far greater degree than less able students, and hence scrambling frame sequence in an instructional program should impair these Ss' achievement to a lesser degree. Similar formulations have led previous investigators of the sequence problem such as Brown (1970), Niedermeyer et al. (1969) and Paine, Kratwohl, and Gordon (1967) to expect such an interaction.

In those investigations a main effect attributable to verbal ability was obtained, but the sought after ATI with sequence was not. The fact that the present investigation involved both familiar and relatively novel materials suggested that an ATI between ability and sequence might be obtained on the unfamiliar materials though not on the familiar.

Method

The basic design for this investigation consisted of the experimental manipulation of the sequence variable, by implementing a logical and scrambled sequence condition, and then studying the ATI of this variable with scholastic aptitude, state, and trait anxiety. The model for this investigation was similar to those recommended by Cronbach and Snow (1969) as especially suited for ATI studies.

Materials

The instructional materials used were similar to those developed in previous studies (Tobias, 1969; Tobias & Abramson, 1971). For the present investigation the continuous 143 frame program previously employed was divided into two separate parts administered at different sessions. The familiar material consisted of the first 54 frames and covered content such as the following: (1) the prevalence and incidence of heart disease; (2) the role of various risk factors such as age, smoking, and cholesterol in increasing the probability of contracting heart disease; (3) the definition of what constitutes heart disease.

The technical, unfamiliar instructional material dealt mainly

with the diagnosis of myocardial infarction from the fifth precordial lead of the electrocardiogram. Medical terminology for different degrees of severity of coronary disease, electrocardiographic tracings characteristic of each level of severity, and graphic representations of the damage to the heart muscle caused by the various levels of coronary disease were included in this part of the program. Each part of the instructional material was followed by its own posttest. The posttests were of the constructed response type, the test for the familiar material had an alpha reliability of .66, and the reliability of the technical posttest had a reliability of .80. The original versions of the complete program and posttest were reproduced elsewhere (Tobias, 1968).

A ten-item Likert type attitude scale designed to determine the feelings of Ss towards instructional material was specifically developed for the present study. A copy of that instrument is reproduced in Appendix A of this report. The same attitude scale was administered both after the familiar and the technical posttest. The alpha reliabilities of this instrument were .80 for its initial administration and .77 for its second administration.

Procedures

Administration of the procedures of this study took two sessions. In the first of these the full A-State and A-Trait Scales together with some other research instruments were administered. The familiar instructional materials were then given to Ss, followed by the posttest and attitude scale. The technical program, posttest, and attitude scale

were administered during the second session. Half of the Ss who had volunteered for this investigation were randomly assigned to a scrambled sequence condition. For this group frame sequence, within the familiar and technical sections of the program, was assigned by means of a table of random numbers.

Both groups received the instructional material in booklet format. The frames were reproduced on one page and the correct answers in the left hand margin of the succeeding page, alongside of the next frame. In both conditions Ss were instructed to record their responses in an answer booklet accompanying the program materials and asked not to check their responses until they had completed them. The group receiving the scrambled sequence was informed that the order of presentation had been randomly varied. During the administration of the technical scrambled program Ss frequently indicated that they had no basis for making a response. They were encouraged to answer if at all possible, otherwise to leave the frames blank and proceed to the next one.

A brief five-item version of the A-State Questionnaire described by O'Neil, Hansen and Spielberger (1969) was administered to Ss at four points: after frame 27 of the familiar program, at the mid-point of the familiar posttest, after frame 44 of the technical material, and in the middle of the technical posttest. The brief A-State Scale was reproduced with standard instructions (Spielberger, Gorsuch, & Lushene, 1969) in the answer booklet accompanying the instructional materials, and on the posttest.

Typically Ss were tested in a classroom in groups of six to twelve.

At least two examiners were present in the room at all times. When Ss finished with one part of the procedures they were asked to raise their hand and the subsequent part of the procedures was administered. The mean interval between the first and second administration was 17.2 days with a standard deviation of 13.8.

Subjects

A total of 120 Ss, of whom 66 were female, volunteered for this study. Three Ss had to be discarded when it was determined that SAT scores were not available for them. Thus the final sample consisted of a total of 117 Ss. Subjects were recruited primarily from educational psychology classes at the City College of New York during the Fall 1969 and Spring 1970 semesters. Ss were told that the purpose of the experiment was to study the effect of program organization, and peoples' feelings on their achievement from programed instruction. All Ss were paie six dollars for their participation.

Results

The critical dependent measures in this investigation were the scores obtained on the two posttests, the errors made on the different sets of instructional materials, and the attitude scores towards the instructional material. In order to allow for direct comparisons between the familiar and technical program and posttest data, these scores were converted to percentages.

The data were analyzed using multiple linear regression techniques (Cohen, 1968). Sequence was represented as a binary vector (1 = regular sequence, -1 = scrambled sequence). The SAT, A-Trait and the appropriate A-State score were represented as continuous vectors. The SAT and A-Trait scores were, of course, the same in the analysis of all the dependent variables. Four different A-State scores were obtained for Ss during the different conditions of the experiment; thus, the A-State score obtained during the familiar program was used for the analysis of percent correct on the familiar program and the scores obtained during the familiar posttest was used during the analysis of those data, and in the analysis of the attitude towards familiar material since that scale was administered immediately after the familiar posttest. The same procedure was followed for the analysis of the technical data, and the respective A-State scores obtained wile S worked on the technical material and posttest were used in these analyses.

A preliminary analysis was conducted to detormine whether A-Trait

and A-State scores interacted with sex, as reported in some previous investigations (O'neil, Hansen, & Spielberger, 1969). Interaction vectors between a binary sex vector and the A-Trait and A-State scores were obtained by the cross multiplication of these vectors. This analysis indicated that there were no interactions between sex and the anxiety scores. Therefore, in the succeeding analysis data for the male and female Ss were pooled.

Multiple linear regression analysis of data such as those collected in this study yields four main effects (sequence, SAT, A-Trait, A-State) as well as a very large number of possible interactions among these variables. In the present investigation only those interaction vectors for which specific hypotheses were formulated were examined. Thus, only the interactions between the manipulated variable, sequence, and scholastic aptitude and the two anxiety measures were examined, as well as the triple interactions among sequence, scholastic aptitude, and the two anxiety measures. This analysis was essentially similar to the model recommended by Cronbach and Snow (1969) as especially appropriate for ATI research.

The full model for each of the dependent variables included those vectors reproduced in Table 1. The succeeding analysis followed a modified step down procedure similar to the one described by Overall and Spiegel (1969) and by Cohen (1968). The significance of main effects was tested by forming a reduced model containing only main effects, and then examining the significance of each variable by dropping its vector from the model, and testing for the reduction of the multiple

correlation. This procedure was followed since some of the main effects were intercorrelated (e.g., r between A-Trait and the abreviated A-State ranged from .09 to .31) and permitted estimation of the percentage of independent variance contributed by each of the variables, adjusted for the effects of all other main effects. Another modification of the step down procedure was to employ the full model in the denominator, rather than only the previous restricted model. This procedure resulted in a more conservative F test than is usually recommended (Cohen, 1968). Interaction effects were examined by adding the interaction vectors in the order in which they appear in Table 1, and their significance tested by comparing the larger model to the prior smaller model, and dividing through with the full model in the denominator.

Table 1, reproduced on the succeeding page, indicates that, as expected, randomizing frame sequence did not have a significant effect on achievement for familiar materials. The obtained F value of 3.25 was significant at the .07 level as determined by the exact procedure (Veldman, 1968) and accounted for 3 percent of the variance. While this result was somewhat closer to achieving statistical significance than had been anticipated, it should be compared to the data for the effect of sequence on the technical posttest. On that variable F = 50.64, of course, significant beyond the .001 level, and that effect accounted for 31% of the total variance. The means and standard deviations, which are reproduced on Table 2 on page 19, indicate that while there was only a slight achievement difference on the familiar

Table 1

Results of Regression Analysis of Program and Posttest Data

	Familiar Program		Technical Program		Familiar Posttest		Technical Posttest	
	Percent Variance	F	Percent Variance	F	Percent Variance	F	Percent Variance	F
Sequence (S)	18	29.73***	65	272.03***	3	3.25	31	50.64***
SAT	2	2.90						
A-State (AS)	a		1	2.58			3	4.35*
A-Trait (AT)	1		1	1.34				
S X SAT		1.08			2	2.90	1	1.17
S X AS					1	1.45	1	1.17
S X AT								
S X SAT X AS	4	6.01*	1	4.84*	6	7.05*		
S X SAT X AT	9	14.86***			2	2.13		

[a] F values of less than 1 not shown.

* $P < .05$

** $P < .01$

*** $P < .001$

Table 2

Means and SDs of Percent Correct on Posttest and Program

	Regular Sequence		Scrambled Sequence	
	M	SD	M	SD
Familiar Program	96.0	4.7	91.7	4.6
Familiar Test	70.2	9.6	66.7	12.8
Technical Program	83.3	9.0	49.4	12.0
Technical Test	62.1	13.8	43.6	14.8

posttest, the achievement difference on the technical posttest was 19%.

There was also a significant sequence effect for the percentage correct on the instructional materials, as indicated in Table 1. For the familiar program the sequence condition yielded an F of 29.73, significant beyond the .001 level and accounted for 18% of the total variance. For the technical program, sequence yielded a highly significant F of 272.03, and accounted for 65% of the total variance. The only other achievement effects approaching significance for these data was the effect of A-State on the technical tests. That variable yielded an F of 4.35, significant beyond the .05 level, and accounted for 3% of the total variance.

The scales measuring attitudes towards the instructional material were administered immediately after both the familiar and technical posttests. Table 3 reproduced on page 22, gives the means and the standard deviations for both groups. The only results of the regression analysis approaching significance were the effects of A-State on attitudes (F = 3.67) and the effects of A-Trait (F = 3.74) both of which were of borderline significance at the .05 level.

The time required to complete both programs and posttests was recorded. The means and standard deviations of these data for all four time periods are reported in Table 4, which is reproduced on page 21. The results of the regression analysis of these data yielded only one consistently significant effect, that of scholastic aptitude. SAT had a positive effect on all time data but the time required to complete the familiar test.

Table 3

Means and Standard Deviations of Attitude Scores Towards Familiar and Technical Material

	Program			
	Familiar		Technical	
Groups	M	SD	M	SD
Regular Sequence	27.5	4.7	20.4	2.2
Scrambled Sequence	27.2	5.1	20.	1.3

Table 4

Means and SDs of Time Taken to Complete Programs and Tests

	Regular		Scrambled	
	M	SD	M	SD
Familiar Program	26.9	6.4	28.8	6.8
Familiar Test	8.4	2.1	9.7	4.8
Technical Program	60.7	12.9	58.8	15.4
Technical Test	12.4	2.2	12.1	9.9

The mean A-Trait score, and mean of the five different administrations of the brief A-State scale are given in Table 5 below. The A-State data indicate that there were few differences among the different times that the scale was administered nor were there difference between the groups.

Table 5

Means and SDs of A-Trait, and Brief A-State Scores for Both Groups.

	Regular Sequence		Scrambled Sequence	
	M	S.D.	M	S.D.
A-Trait	41.4	9.7	39.6	8.5
A-State Pre	11.0	3.0	10.0	2.9
A-State Familiar Program	9.8	3.2	9.4	3.2
A-State Familiar Test	10.9	3.0	10.4	3.4
A-State Technical Program	8.9	3.0	10.6	4.1
A-State Technical Test	10.3	3.0	9.9	3.9

Discussion

The results of this study provide striking confirmation for the central contention that the effect of sequence was modified by S's prior familiarity with the instructional material. At the same time the results provided only minimal evidence of ATIs among sequence, anxiety, and intelligence. The significance of these findings, and implications for future research will be discussed below.

Sequence

As predicted the sequence variable had a significant effect on achievement only for the technical, unfamiliar subject matter. For these data the sequence variable accounted for 31% of the overall achievement variance. For familiar material, on the other hand, sequence did not have a significant effect. In view of the fact that both sets of materials were drawn from the same domain, the area of heart disease, the interpretation that the achievement differences can be attributed to the degree to which the materials were either novel or familiar is strengthened.

In addition to the evidence from the achievement data, observational evidence of Ss working on the materials also strengthened a familiarity interpretation. When Ss who had been randomly assigned to the scrambled condition were given the familiar program, they proceeded to work on these materials much as if they had been logically sequenced. When these same Ss were given the scrambled technical program, however, the behavior of this group can best be described as confusion and consternation. These Ss frequently asked what they were to do despite

the fact that printed instructions had been distributed. Other Ss asked whether a portion of the instructions had been accidentally omitted. Many Ss commented on the fact that they had no basis for making answers to some of the frames since the material was quite strange to them. The striking difference in behavior for the same Ss taking the scrambled familiar and technical programs strongly confirmed the familiarity interpretation. On the familiar program Ss appeared to have little difficulty determining what types of responses to make to the program. Even though Ss in the scrambled group made a significantly greater percentage of errors on the familiar material ($F = 29.73$, $p < .001$) they had sufficient familiarity with the material to know the kind of response expected though they may have missed the precise answer to a particular frame. On the technical program, however, Ss' behavior and comments indicated that they had no basis for making responses of any kind. They frequently, thus, omitted making responses of any kind. The high frequency of omitted responses on the technical program accounts for the fact that there were no differences between the scrambled and the regular group on the amount of time required to complete the program. Thus, both the achievement data and the observation strongly support the interpretation that the logical sequence is a prerequisite for content to which Ss had not been previously exposed. For content familiar to Ss, sequence appears to be considerably less important.

An interpretation of the results of this experiment in terms of the hierarchical structure of subject matter (Gagné, 1968; Brown,

1970) appears possible. A detailed inspection of both the familiar and technical programs suggests that the technical program appears to have a more rigorously hierarchial structure than does the familiar material. Present data, thus, do not permit a definitive interpretation that Ss' familiarity is the critical variable in the importance of sequence. A critical test between these interpretations would be to selectively pre-familiarize Ss with some of the subject matter in either of the programs, and then to determine the relative importance of the hierarchial structure of the subject matter, or Ss' familiarity with it as the critical variable.

It appears possible that interpreting the results in terms of hierarchy, or in terms of Ss' familiarity are more similar than would first appear. It seems clear that a person's familiarity with a particular body of context is probably of major importance in determining the hierarchy of that body of content for him. One would expect that for adults in this culture, there are relatively few concepts which are strictly hierarchial in the sense advocated by Gagné (1968). That is, there are relatively few concepts which could not be learned at all by the typical adult without mastering of the requisite subordinate content. One would suspect, instead, that mastery of these subordinate skills might lead to more efficient acquisition rather than preventing them from learning it at all. Even for a highly hierarchial body of knowledge intelligent Ss, such as the college students used in this study, can probably "figure out" the subordinate concepts while working on the superordinate materials. Such figuring out of the entire material

obviously alters the hierarchy of the subject for them. If the present analysis is correct, the hierarchy of the subject matter does not exist independently of a person's familiarity with a particular domain, but instead is dependent upon the person's experience with a particular area.

Prior familiarity with subject matter has an important heuristic advantage over the hierarchial conception. A person's previous familiarity with a particular domain is easily assessed by a detailed pre-test on that content. The hierarchy, on the other hand, is not as easily defined operationally. Bunderson (1971) indicated that different individuals constructed markedly different hierarchies of the same subject matter. The reliability of a particular hierarchy is thus subject to some dispute. On the other hand a person's prior familiarity is somewhat less equivocal in the view of the fact that it can easily be defined in operational terms as the score on a particular pre-test. The clarity of such definition is of some importance with respect to its communicative relevance. Furthermore, should the importance of Ss' prior familiarity with a particular body of content be confirmed by further research it is a variable of some attractiveness to researchers in educational psychology. Not only is it possible to define prior familiarity by a score on a particular pre-test, but it is also relatively simple to manipulate these variables experimentally by selectively pre-familiarizing random groups of students with some aspect of the subject matter, or all of the subject matter, and thus studying the effects of such familiarization.

ATI

There was some evidence for interaction among the variables in this study; however, on the whole the results can be said to be more disappointing than encouraging with respect to the ATI construct.

Interactions had been predicted on the technical subject matter where, but for one exception, they did not appear, and not on the familiar material where they did appear. There was a significant interaction among sequence, SAT, and A-State Anxiety. Figures I and II, reproduced on the succeeding pages, indicate that this is an ordinal interaction (Cronbach & Glaser, 1965). Figure I indicates that in the scrambled sequence the percentage correct on the familiar program increases as SAT scores go up. For the regular sequence there is no relationship between these variables. This finding suggests that the ablest students could overcome the effects of scrambling the subject matter and supply correct answers even though the program support offered by the continuity of subject matter was absent.

Figure II depicts this interaction with respect to A-State data. For the logical sequence achievement on the program increased as A-State decreased. Data for these Ss appeared to show a mild disrupting effect attributable to A-State. On the other hand, for the scrambled sequence a slight positive relationship between A-State and percent correct was observed. This interaction may be attributed to the possibility that when A-State went up S paid closer attention to the programed material.

The triple interaction among sequence, SAT, and A-Trait anxiety

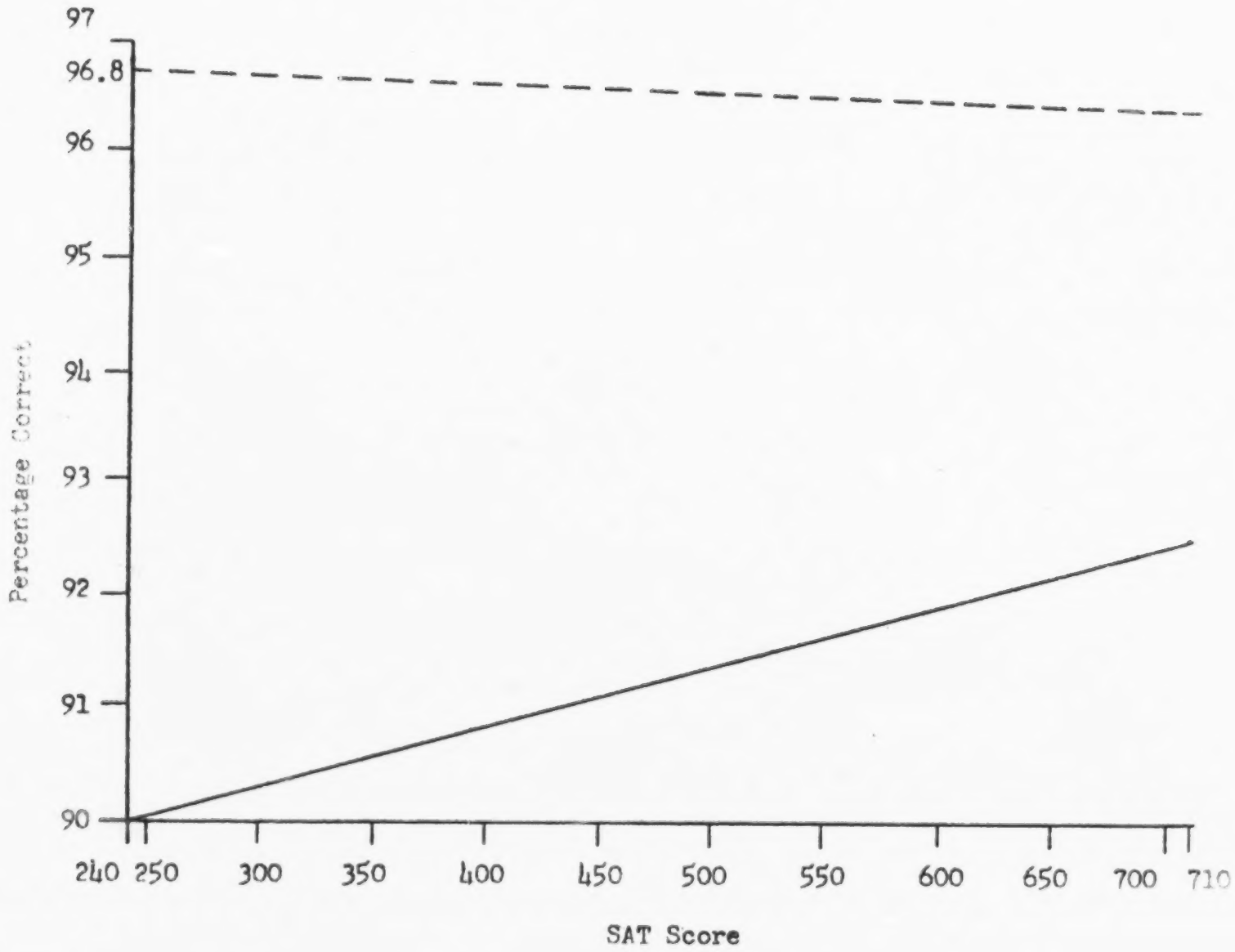

Figure 1. SAT Score and Percentage Correct on Familiar Program for both Groups.

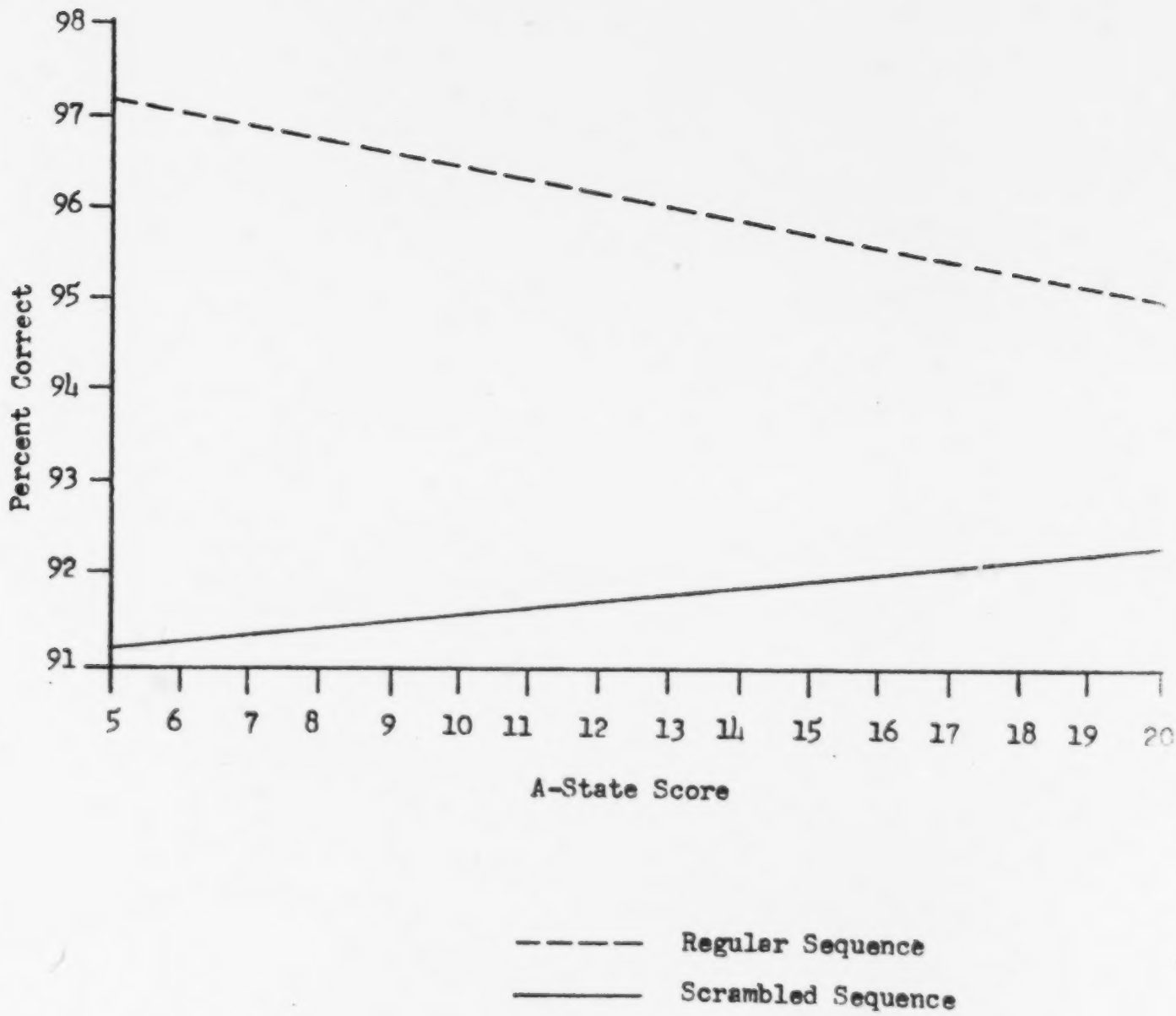

Figure 2. A-State Score and Percent Correct on Familiar Program.

is depicted in Figure III, on the next page. This interaction is also ordinal and indicates that for the logical sequence as A-Trait Anxiety increased percentage correct on the program also increased slightly. On the other hand for the scrambled subjects the angle of the curve is essentially flat. The contribution of verbal ability to this interaction was, of course, depicted in Figure I and discussed above.

The interactions among sequence, A-State, and SAT on the familiar test are depicted in Figures IV and V which are reproduced on the succeeding pages. Both of these interactions are disordinal. As Bracht (1970) points out, there are not tests to determine the significance of the cross-over region when regression techniques are used. Inspection of these graphs, however, suggests that it is unlikely that the cross-over area was significantly different. Figure IV indicates that for the scrambled sequence there was a positive relationship between SAT score and achievement on the familiar posttest, while this relationship was negative for the logical group. The positive relationship for the scrambled sequence suggests that these Ss had to override the effect of scrambling and hence the relationship between verbal ability and achievement was obtained. The negative relationship for the logical sequence was, however, surprising. One might speculate that for these Ss ability was less important than the attention and care devoted to the program.

Figure V depicts the interaction on the familiar posttest with respect to A-State. These data show a strong negative relationship between A-State and achievement for Ss receiving the logical sequence.

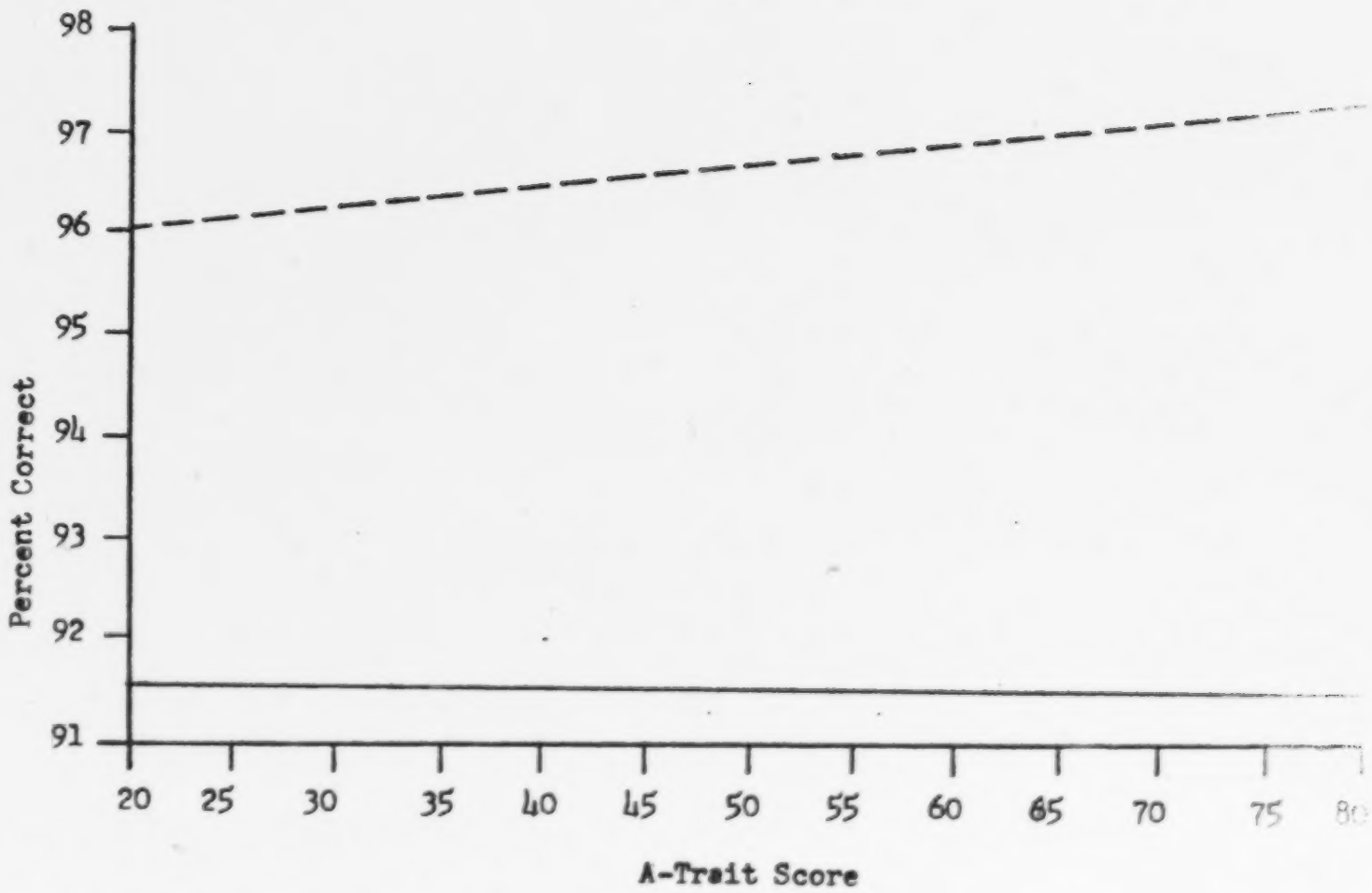

Figure 3. A-Trait Score and Percent Correct on Familiar Program.

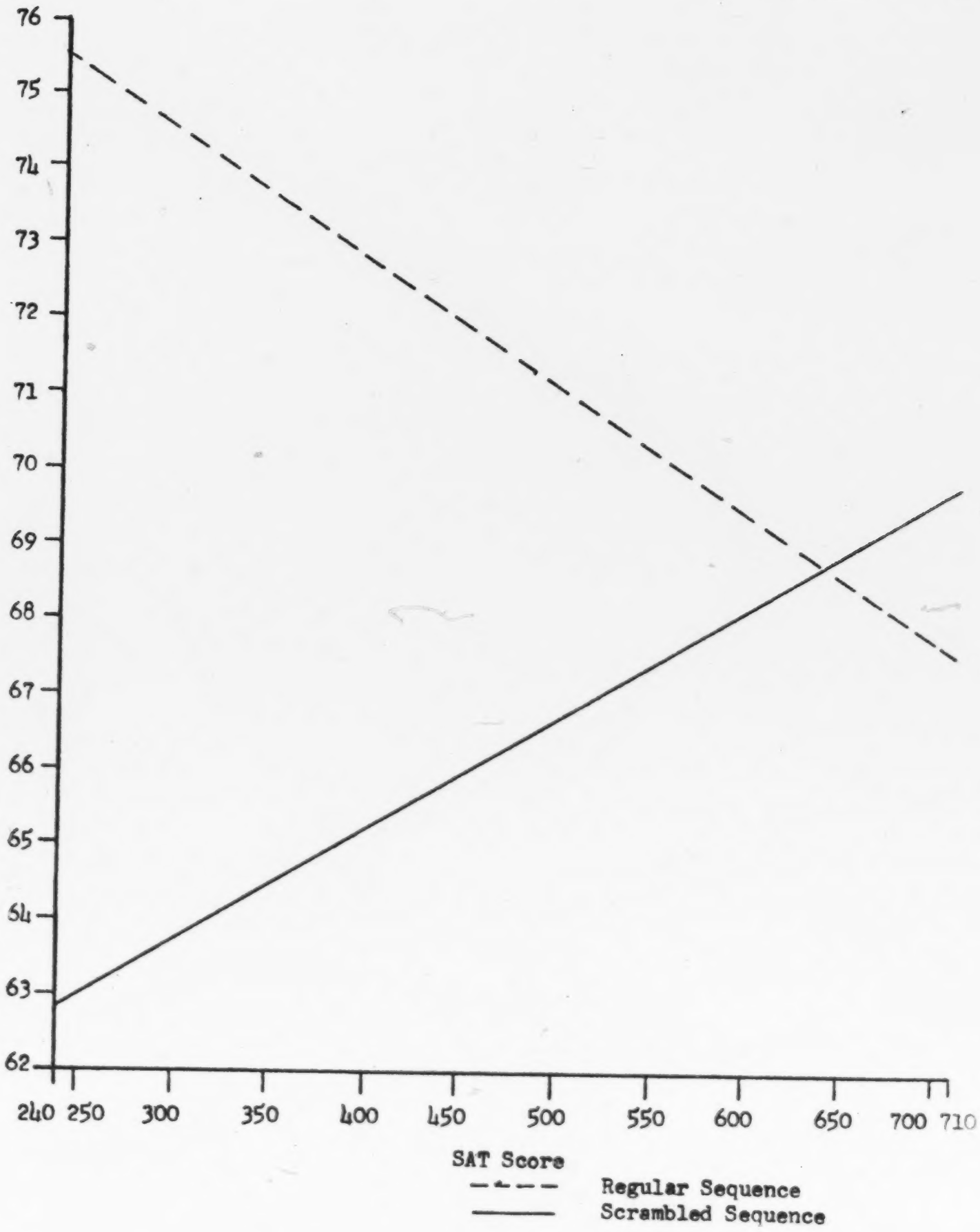

Figure 4. SAT Score and Percentage Correct on Familiar Test.

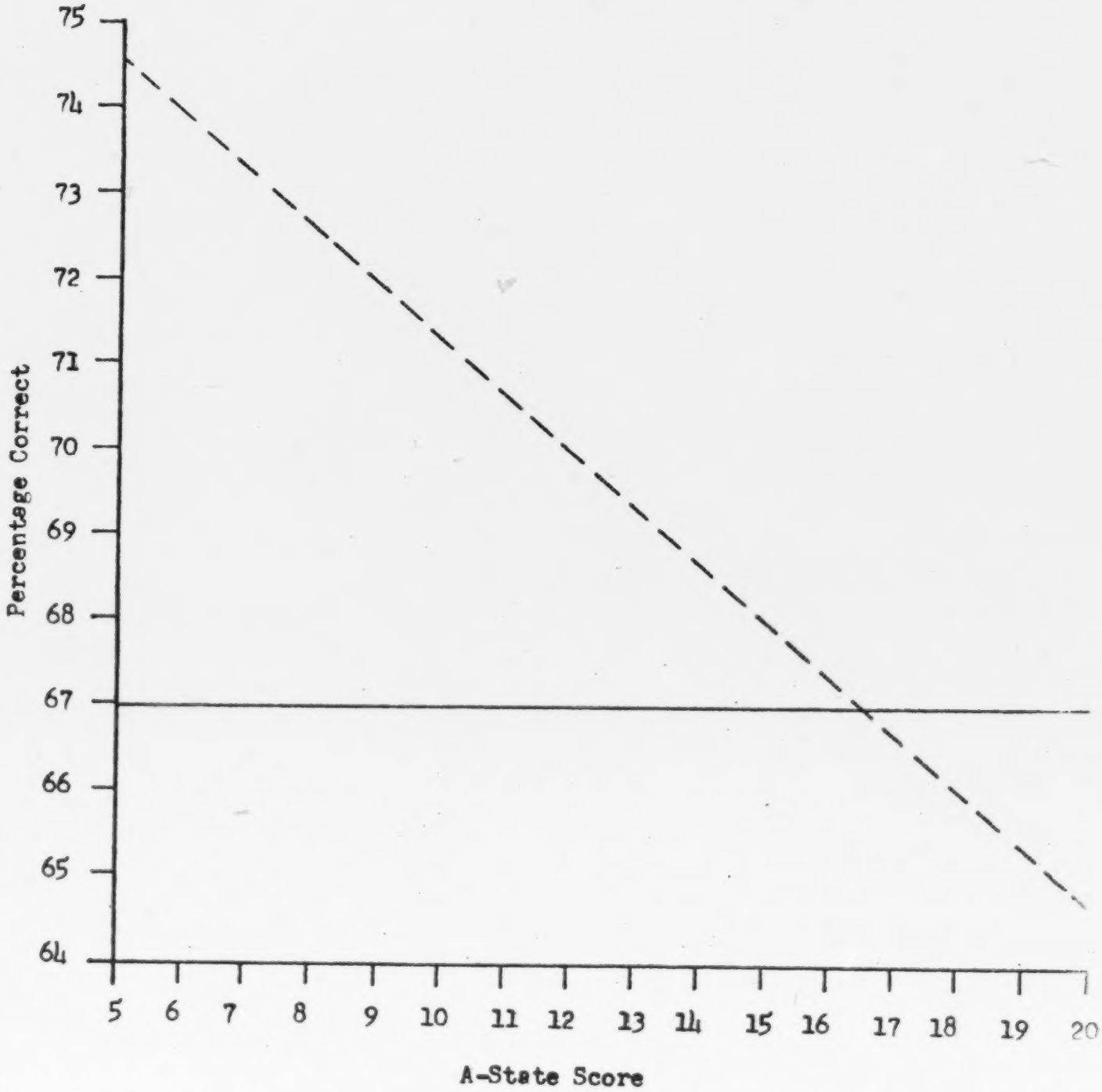

Figure 5. A-State Score and Percentage Correct on Familiar Test.

Clearly, Ss with high A-State achieved less than those with low anxiety. For the scrambled sequence, on the other hand, there appeared to be no relationship between A-State and achievement. The difference in these relationships cannot be ascribed to different intensities of anxiety on this sub-test, since the mean A-State scores on the familiar A-State scores on the familiar test for both groups were 10.9 for the logical sequence, and 10.4 for the scrambled sequence. The meaning of this interaction is thus obscure.

Figures VI and VII, reproduced on succeeding pages, depict the triple interaction among sequence, A-State Anxiety and SAT on the technical program. Again both of these interactions are ordinal. Figure VI indicates slight relationships between achievement of the technical program and SAT, though there are slight differences in the slopes of the two lines. Figure VII depicts positive relationships between A-State and achievement for both groups though the slopes of both groups are somewhat different. What is more remarkable than the slight differences in the slope on both Figures VI and VII are the huge differences in terms of the elevations of these curves. It is clear for these data that the mild interaction observed accounts for very small percentage of variance compared to the huge variance attributable to sequence.

The failure to find stronger interactions among anxiety and sequence on the unfamiliar content may be attributed to several factors. Of greatest importance among these was the reaction of the scrambled group to the technical program. These Ss clearly did not know how to

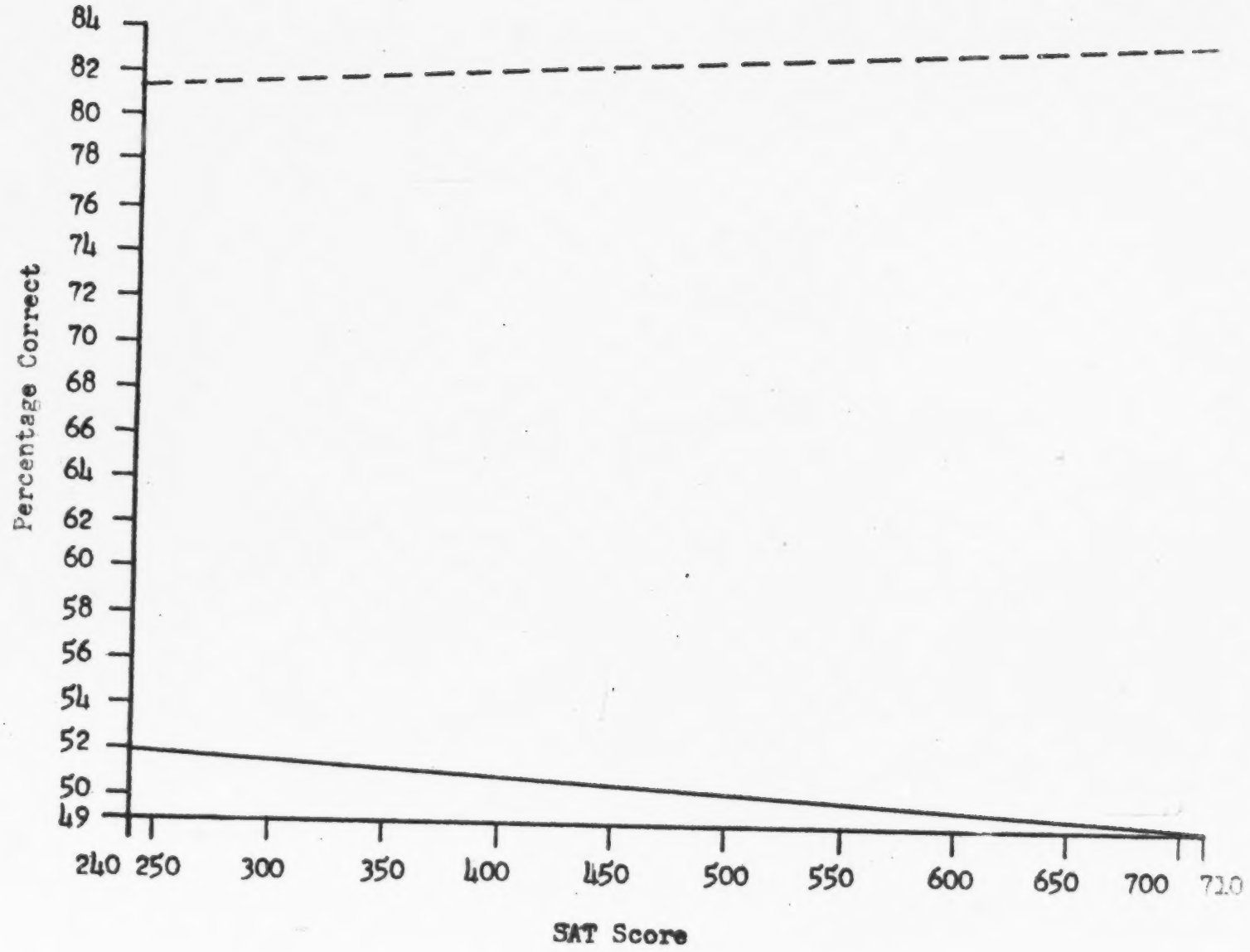

Figure 6. SAT Score and Percentage Correct on Technical Program.

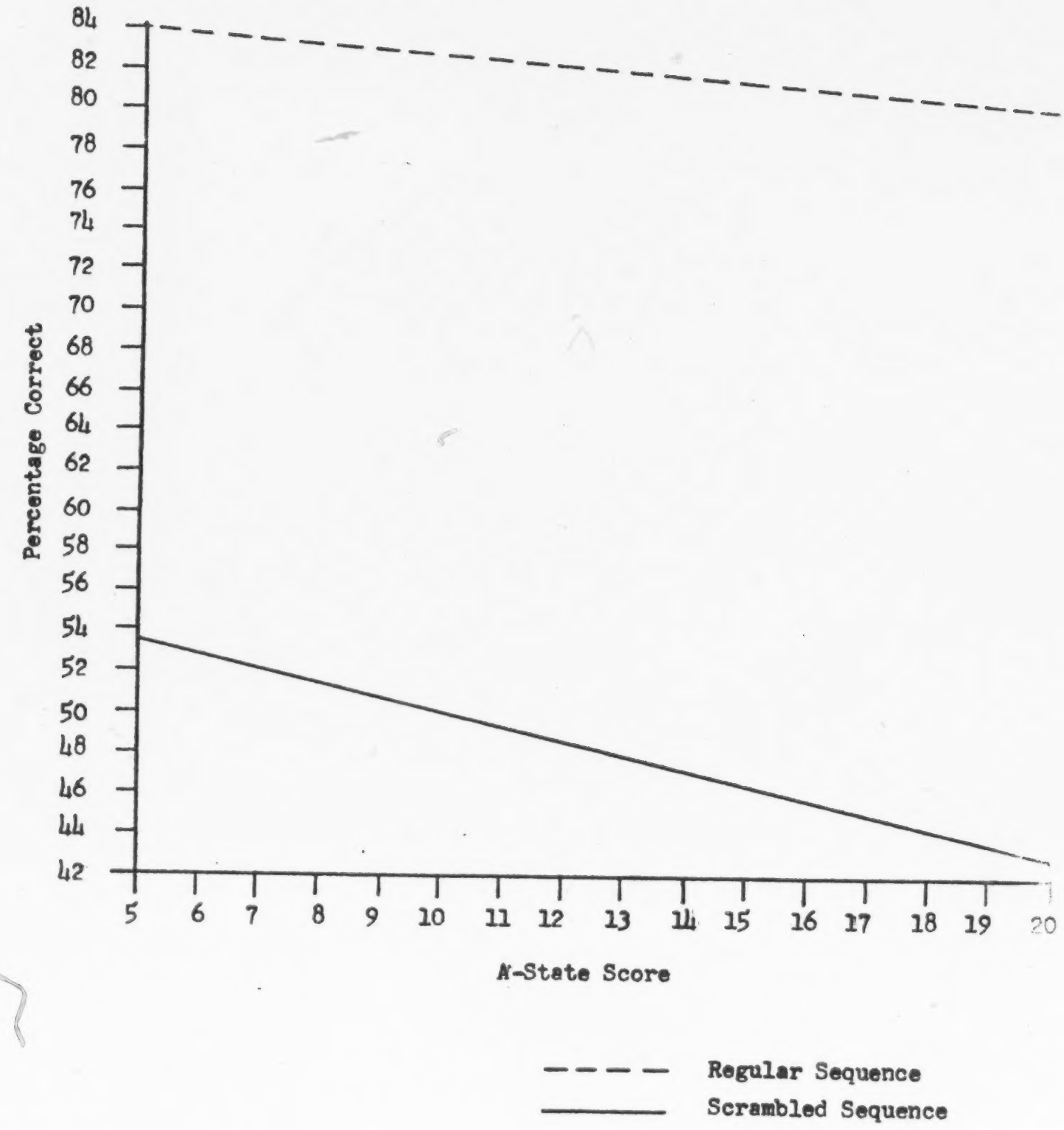

Figure 7. A-State Score and Percentage Correct on Achievement on Technical Program.

proceed, and viewed the task as an impossible one. On the program the scrambled group left an enormous number of the responses blank, and even though they had been instructed not to look ahead at the answer, observation suggested that they frequently did. One would suspect that for these Ss errors on the program had little effect on their evaluation of themselves and was attributed mainly to the confusing nature of the task. The fact that Ss were not required to make a response prior to proceeding to the next frame, and could look ahead at the answer left little opportunity for anxiety to build up. In such a situation strong interactions with anxiety could not, of course, be expected.

In this investigation, as in previous studies (Tobias, 1969a, b; Tobias & Abramson, 1971) Ss' prior familiarity with the content taught was of importance in determining which instructional treatment led to optimal achievement. In the present study scrambling exerted a strong effect on material with which Ss had little prior familiarity, whereas the effect on the material with which Ss had experience was small. In previous studies familiarity was shown to be of importance with respect to which mode of responding to the material led to optimal achievement. Typically, constructing responses led to superior achievement for technical, novel content and not for familiar materials. The consistency of these findings strongly suggests an interaction between instructional variables and familiarity. It would seem profitable to explore the familiarity variable further. Studies in which Ss' familiarity is varied together with different instructional treatments might serve to clarify the effects of familiarization.

In recent symposia devoted to the ATI problem (Carrol, 1969; Glaser, 1970; Snow & Bracht, 1971) much attention has been devoted to the importance of task specific attributes in generating ATIs. Task specific attributes would pose an enormous problem to ATI researchers. An interaction between instructional treatments and an attribute which is highly specific to the task would, of course, be of limited heuristic importance since only the specific subject matter used in the particular investigation would be clarified by such a finding. From a researcher's point of view findings which do not generalize to other areas are, of course, useless. The findings of the present investigation, together with the findings of previous studies discussed earlier, suggest that there may be a way out of the paradox of assessing task specific behavior, yet still be able to generalize these to other bodies of content. If Ss' familiarity with subject matter can be shown to interact with different instructional treatments in a number of areas this familiarity with the material would of course, be specific to the particular task; the level of familiarity may, however, be generalizable from one content area to another. These data suggest that extent of familiarity as determined by specific pretests, or experimental prefamiliarization may be shown to interact with instructional variables in a variety of content areas. Such findings imply the hypothesis that it is prior achievement, or learning which may interact with different instructional treatments rather than aptitudes or attributes.

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Appendix A. Attitude Scale.

NAME _____ S# _____

Please answer the following questions in terms of how you feel about the program you have just completed. Indicate your feelings by circling the choice which most accurately reflects your opinion.

1. How did you feel about the way the material was presented?

Enjoyed presentation	Presentation moderately pleasant.	Presentation moderately unpleasant.	Disliked presentation.

2. Did you find yourself just trying to get through the material, rather than trying to learn?

All the time	Most of the time.	Some of the time.	Never

3. Did you know whether your answers were correct before checking them?

All the time	Most of the time.	Some of the time.	Never

For the following items please check your answer in one of the boxes at the right.

	Definitely	Probably	Probably not	Definitely not
4. Would you like to learn other subjects by the same format?				
5. Did you feel that this format made it harder for you to learn the subject?				
6. Do you feel that this format helped you learn the material more rapidly than you would have learned it from a non-programed format?				
7. Did you feel that the format made it more difficult for you to concentrate on the material than a non-programed format?				
8. Did you feel more certain about knowing the subject matter than you would have if it were presented in a non-programed manner?				
9. Did you feel that this format made learning more mechanical?				
10. Would you like to learn more about the principles of programed instructions?				

If you have any further comments please write them out on the back of this sheet.